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HAWAII'S GEOTHERMAL FUTURE AND THE DEEP WATER CABLE

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ABSTRACT

The State of Hawaii presently utilizes costly imported fuel-oil for over 90 percent of its electrical power generation. With the uncertainties associated with the price and supply of this oil, the State has set, as one of its highest priorities, a goal of electrical energy self-sufficiency. Geothermal power, because of its proven technology and apparent abundance, appears to be the major hope for achieving this goal within the immediate future. A problem exists, however, in transporting the electricity generated from a potentially large resource on the Island of Hawaii to the market on the Island of Oahu. This paper discusses geothermal activities in Hawaii and the relationship of a deep water power cable demonstration program to those activities.

INTRODUCTION

The State of Hawaii is blessed with, among many other assets, abundant indigenous renewable alternate energy resources (DPED and LBL, 1981). Continuing research, development and demonstration (RD & D) programs have shown the viability of harvesting the energy of the earth's heat, winds, waters and plants to produce electricity. Some of these sources have, in fact, been developed to the extent of making a significant contribution to offsetting the amount of costly imported fuel-oil required for conventional electrical power generation.

Table 1 lists the present methods of electrical power generation on the various islands of the State.

Table 1

Electrical Power Generation Methods

Island	Generating Capacity (MW)	Generating Method (percent) Oil-Fired	Biomass	Hydro
Kauai	105	55.2	32.0	12.8
Oahu	1209	98.3	1.7	-0-
Molokai	5	100.0	-0-	-0-
Maui	112	79.4	19.1	1.5
Hawaii	124	60.9	33.6	5.5
TOTALS	1555	91.0	7.6	1.4

Although significant inroads have been made on individual islands (primarily Hawaii and Kauai) to reduce the dependency on oil, statewide use of fuel-oil for electrical power generation still remains at a greater than 90 percent level. It is evident, therefore, that work still remains to achieve the State of Hawaii's goal of electrical energy self-sufficiency.

The development of geothermal energy and of an interisland underwater cable system are basic necessities to this achievement (DPED and LBL, 1981).

HAWAII'S GEOTHERMAL PROGRAM

Appreciation of the geothermal energy potential in the State begins with an understanding of the volcanic origins of the islands. The eight major islands (seven of which are populated) and the numerous minor islands, are little more than the peaks of an extensive underwater volcanic mountain range. The eight major islands are shown in Figure 1 (Kahoolawe is the unpopulated island). Based on the volcanic process that formed the island chain, Kauai is the oldest island while the island of Hawaii (known as the "Big Island") is the youngest. Volcanic activity on the Big Island has occurred as recently as April/May, 1982.

Using the knowledge of the State's volcanic origins, geothermal resource exploration drilling began in 1961 at one of the more promising sites on the Big Island. After several unsuccessful attempts, the first successful well was flashed on July 2, 1976. Known as HGP-A (Hawaii Geothermal Project - "A" for Agatin Abbott, chairman of the site selection committee), this well was drilled to a depth of 6,450 feet. The bottom hole temperature of 676 degrees F made this geothermal well one of the hottest in the world.

Following the discovery of this well in the Puna District of the Big Island, a 3 MW wellhead geothermal generating plant was constructed through the cooperative efforts of the DOE, State and County. This plant, which is powered by the HGP-A well, began commercial operation on February 12, 1982. Construction costs for this 3 MW plant were $8.5 million ($2,833/kw). Drilling costs for the HGP-A well were $1,609,000.

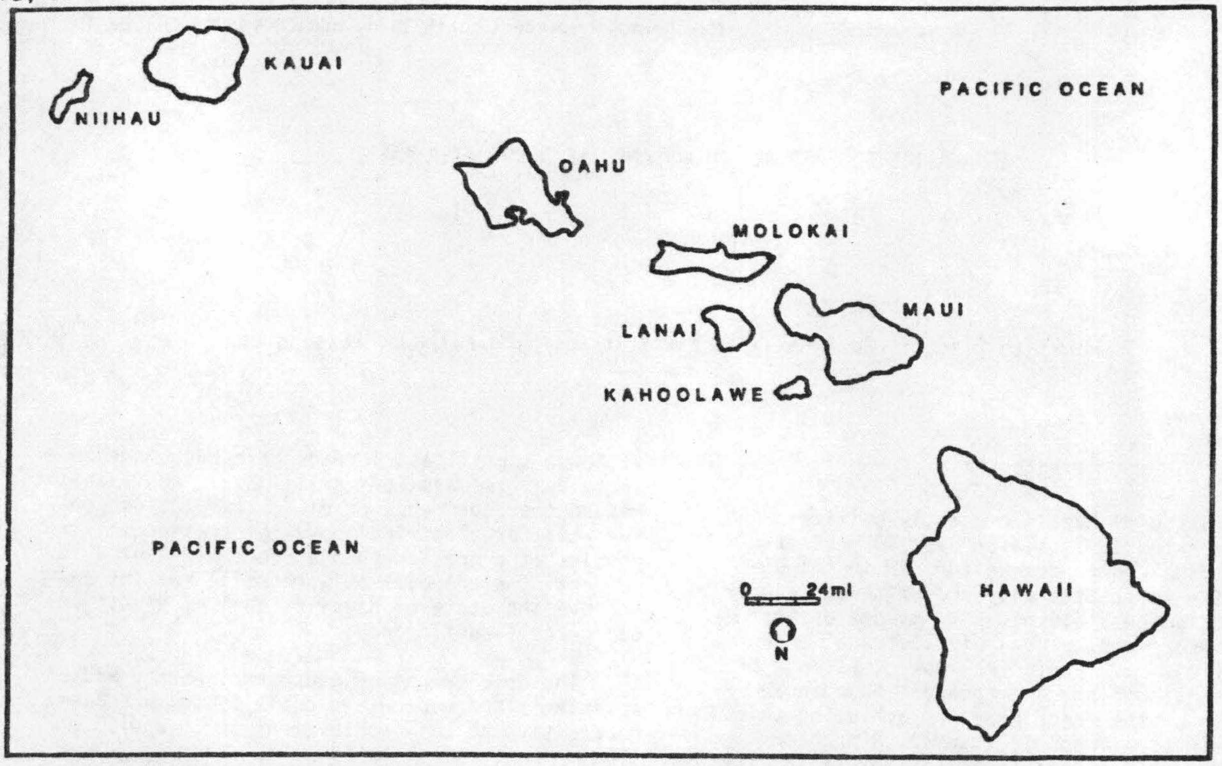

Figure 1. Major Hawaiian Islands

This successful demonstration of a geothermal resource generating electric power provided an added incentive to three private geothermal resource development organizations who responded to the Hawaii Electric Light Company (the Big Island's utility) Request-for-Proposal (RFP) for a 25 to 50 MW geothermal electric power development project. The RFP covers the areas of 1) exploration and development of geothermal well fields, 2) design and construction of geothermal power plants, and 3) sale of the electrical energy produced to the Hawaii Electric Light Company.

The three companies are presently performing resource confirmation and development work to satisfy not only the RFP, but, more importantly, to confirm the existence of a presently estimated geothermal resource of 1000 MW of electrical power. It is interesting to note that these companies have taken two diverse approaches to the question of geothermal development.

Two organizations are actively drilling exploratory wells to confirm the resource and to test the longevity and quality of the resource. Subsequent to this activity, these two organizations will plan the development of their respective resources and secure additional permits to develop well fields and construct power plants. The third organization has chosen to acquire all necessary permits/approvals for the full development of 250 MW of geothermal resources prior to the initiation of any drilling activities. Since the potential geothermal resources of this latter organization are situated on landholdings zoned for conservation district purposes, acquisition of the permits/approvals is a major constraint in their plans.

Present forecasts indicate that the Big Island cannot accept more than 40 to 50 MW over the next 30 to 40 years. Unless another viable market is found, the full potential of the Big Island's geothermal resource will not be realized. As implied by Table 1, the largest load center is on the Island of Oahu where the additional generation can be accepted into its electrical system. It is anticipated that, if a means of transporting the electrical power to Oahu can be found, a significant block of power could be accepted for use immediately (Okura and Chapman, 1982a). Out of the need to transport the potentially huge block of power grew the Hawaii Deep Water Electrical Transmission Cable Demonstration (HDWC) Program.

THE HDWC PROGRAM

Under most circumstances, the electrical interconnection of the islands in the State via an underwater cable system would be an achievable task. For example, the electrical linking of the islands of Molokai, Maui and Lanai using presently available underwater cables and cable-laying vessels has been deemed to be feasible (Hwang and Young, 1979). Similar type cables have been utilized to intertie islands in Japan and to interconnect Vancouver Island with mainland Canada. High voltage direct-current (HVDC) underwater cables have been installed in Europe to link many areas including Norway and Denmark. The

Skagerrak Cables, as this latter system is commonly called, are deployed to a depth of approximately 1,800 feet and over a distance of about 78 miles. They are the deepest and longest HVDC cables deployed to date (Hauge, et al., 1978).

As noted earlier, however, in Hawaii the major potential source of alternate energy electrical power, specifically geothermal, is on the Big Island while the major marketplace is Oahu. Separating these two locales are the Alenuihaha Channel (between the Big Island and Maui) which is approximately 7,000 feet deep and the Kaiwi Channel (between Molokai and Oahu) which is approximately 2,200 feet deep. Further, depending on the routing of the cable system, lengths ranging from 130 to 260 miles would be encountered. Because the depths and distances noted will be encountered in the establishment of a Hawaiian interisland cable system, cables capable of withstanding deployment tensions of over 125,000 pounds and water pressures up to 3,000 psi must be designed, tested and proven reliable and economically feasible (Chapman, 1981).

The HDWC Program was therefore designed with three major goals. First, to determine the technical and economic feasibility of establishing an interisland electrical grid system. Second, to determine the ocean engineering problems and solutions of deploying, retrieving and repairing a deep water cable. And third, to develop a deep water cable criteria document that can be used for the design, installation and maintenance of deepwater electrical transmission cable systems (Okura and Chapman, 1982b).

The HDWC Program was initiated in 1981 with the release of $300,000 of State of Hawaii funds for the Phase I, Preliminary Definition Study, work efforts. This phase of work was completed in late April, 1982, when the results of the five major tasks were submitted to the State of Hawaii's Department of Planning and Economic Development.

The five major tasks consisted of two administrative-type tasks and three technically-oriented tasks. The administrative tasks resulted in the preparation of program planning/management documents, schedules and costs which will be used to guide the program in future phases of work. The technical tasks were preliminary studies covering 1) cable routes, 2) cable designs and 3) cable vessel and handling equipment designs (Okura and Chapman, 1982b).

The preliminary cable route survey has resulted in the identification and analyses of over 40 separate routings or route segments for an electrical intertie between the Big Island and Oahu. The selection of a preferred alignment will depend on additional economic, system planning, environmental and at-sea survey studies to be conducted in future phases. For the cable design task, detailed analyses of 16 candidate designs were performed and five were selected for further consideration. Additional mechanical/electrical analyses and cost-benefit studies to be conducted in future phases will result in a preferred cable design. This design will be the basis for manufacture of a test length to be deployed in the Alenuihaha Channel. Finally, the cable vessel and handling equipment task has resulted in a thorough literature search of presently available vessels and equipment and a preliminary conceptual design of the vessel and equipment to be used on the HDWC Program. Future phases of work on this task will include additional design and cost tradeoff studies to determine not only the HDWC requirements, but also the ultimate cable vessel and handling equipment needs.

Federal and State funding support have been requested for the presently estimated $17 million HDWC Program. This multi-phase program, scheduled for completion in December, 1984, has brought together a multi-discipline team composed of a public utility, a program management specialist, a cable manufacturer, a cable vessel/handling equipment specialist, and various State organizations. It is signficant to note that, similiar to the initial geothermal development activity, government funding support is required since none of the above program participants could, individually, support the high risk, high technology, long-term investment nature of deep water cable design and manufacture.

CONCLUSION

This paper is a brief summation of geothermal power development activity in the State of Hawaii and the important role to be played by the HDWC Program in the successful development of the large potential geothermal resource. It is clear that, without the HDWC Program, geothermal power could not be developed to the maximum extent practicable. Conversely, without the emphasis placed on geothermal development, the HDWC Program would not be required. Hence, both programs are proceeding concurrently and it is acknowledged that, if one fails to meet its goals, activities on the other could substantially decrease or stop altogether.

If, however, both programs should successfully meet its goals, a significant step will have been taken towards achieving the State of Hawaii's goal of electrical energy self-sufficiency.

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